

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ALIGN TECHNOLOGY, INC.,

Petitioner,

v.

DENTAL MONITORING SAS,

Patent Owner.

Case No. IPR2023-01369

U.S. Patent No. 10,755,409

PATENT OWNER'S RESPONSE

Mail Stop **Patent Board**
Patent Trial and Appeal Board
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PATENT OWNER'S UPDATED EXHIBIT LIST

Exhibit Number	Description
2001	Declaration of Joshua A. Krevitt in Support of Patent Owner's Motion for <i>Pro Hac Vice</i> Admission
2002	Declaration of John Mongan, dated December 7, 2023
2003	Curriculum Vitae of John T. Mongan, MD, PhD
2004	Redline of Carrier against the Carrier Provisional
2005	GeForce GTX TITAN X Specifications
2006	Andri et al., <i>YodaNN: An Architecture for Ultralow Power Binary-Weight CNN Acceleration</i>
2007	Shrestha and Dang, <i>Deep Learning-Based Real-Time Auto Classification of Smartphone Measured Bridge Vibration Data</i>
2008	<i>Dental Monitoring SAS v. Align Technology, Inc.</i> , Case No. 22-cv-07335, Dkt. No. 59, Order Denying Second Motion to Dismiss (N.D. Cal., July 19, 2023)
2009	<i>Dental Monitoring SAS v. Align Technology, Inc.</i> , Case No. 22-cv-07335, Defendant's Patent Local Rule 3-3 and 3-4 Initial Invalidity Contentions and Disclosures (N.D. Cal., Sept. 11, 2023)
2010	<i>Dental Monitoring SAS v. Align Technology, Inc.</i> , Case No. 22-cv-07335, Dkt. No. 86, Align's Notice of Pending Inter Partes Review Petition (N.D. Cal., Oct. 5, 2023)
2011	<i>Dental Monitoring SAS v. Align Technology, Inc.</i> , Case No. 22-cv-07335, Dkt. No. 92, Order Re Updated Patent Showdown Deadlines (N.D. Cal., Oct. 26, 2023)
2012	<i>Dental Monitoring SAS v. Align Technology, Inc.</i> , Case No. 22-cv-07335, Dkt. No. 56, Patent Showdown Scheduling Order (N.D. Cal., July 14, 2023)

Exhibit Number	Description
2013	<i>Docket Navigator Report on Time to Trial in cases before Judge Alsup (Excluding Outliers)</i>
2014	[Reserved]
2015	[Reserved]
2016	[Reserved]
2017	[Reserved]
2018	[Reserved]
2019	[Reserved]
2020	The PASCAL VOC 2012 Segmentation dataset (July 13, 2017 version available at https://web.archive.org/web/20170713000522/http://host.robots.ox.ac.uk/pascal/VOC/voc2012/#data)
2021	[Reserved]
2022	[Reserved]
2023	[Reserved]
2024	[Reserved]
2025	[Reserved]
2026	[Reserved]
2027	[Reserved]
2028	Expert Declaration of Dr. John T. Mongan, M.D., Ph.D., in support of Dental Monitoring's Patent Owner's Response
2029	Updated Curriculum Vitae of John T. Mongan, M.D., Ph.D.

Exhibit Number	Description
2030	Expert Declaration of Dr. Budi Kusnoto, D.D.S., M.S., in support of Dental Monitoring's Patent Owner's Response
2031	Curriculum Vitae of Budi Kusnoto, D.D.S., M.S.
2032	American Association of Orthodontists, <i>2023 Economics of Orthodontics Analysis Reporting on 2022 Practice & Patient Statistics: Member Report</i> (Aug. 28, 2023)
2033	American Board of Orthodontists, <i>Ideal Photographs and Radiographs</i>
2034	Institute of Medical Illustrators, <i>IMI National Guidelines: Orthodontic Photography</i> (Feb. 2008).
2035	Canon, <i>Canon Dental Photography Guide</i> (2015)
2036	Excerpts from Transcript of Deposition of Dr. Maureen A. Valley in IPR2019-00132 (Dec. 18, 2019)
2037	Excerpts from Declaration of Dr. Maureen A. Valley in <i>Dental Monitoring SAS v. Align Technology, Inc.</i> , 3:22-cv-07335-WHA (Dkt. 104-5)
2038	R. Kaplan, <i>Standardization for Serial Intraoral Photography</i> , The C.V. Mosby Co. 431 (1979)
2039	J. Liu et al., <i>Machine Learning in Orthodontics: Challenges and Perspectives</i> , 30(10) Adv. Clin. Exp. Med. 1065 (2021)
2040	S. Samawi, <i>Clinical Digital Photography in Orthodontics: Professional Photographic Records in Daily Practice</i> , 18 Jordan Dental J. 20 (2012)
2041	O. Russakovsky et al. <i>ImageNet Large Scale Visual Recognition Challenge</i> , https://arxiv.org/pdf/1409.0575
2042	S. Xie & Z. Tu, <i>Holistically-Nested Edge Detection</i> , https://arxiv.org/pdf/1504.06375

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2043	M. Owen, <i>How iPhone Speeds Have Grown in the Last 5 Years</i> , Apple Insider (Sept. 26, 2022), https://appleinsider.com/articles/22/09/26/how-iphone-speeds-have-grown-in-the-last-5-years
2044	Apple, <i>iOS 11 is Available Tomorrow</i> , Apple Newsroom (Sept. 18, 2017)
2045	B. Lang, <i>NVIDIA's Next-Gen Titan X Has 11 TFLOPS Performance, 12GB of Memory, and Costs 1 Arm and 1 Leg, Road TOVR</i> (July 21, 2016)
2046	I. Ahmad, <i>Digital Dental Photography, Part 2: Purposes and Uses</i> , 206(9) British Dental J. 459 (May 2009)
2047	S. Finlay, <i>Photographic Analysis and Diagnosis: Step One</i> , 2(3) <i>Inside Dentistry</i> (Oct. 2009)
2048 ¹	Deposition Transcript of Dr. Hassan Foroosh, Ph.D., in IPR2023-01269 (May 17, 2024)

¹ Patent Owner is not yet in receipt of the witness's signature or the officer's certification and will coordinate with Petitioner to file an updated exhibit once complete. 42.53(f)(5)-(6).

I. Introduction

Patent Owner, Dental Monitoring SAS, respectfully submits that the Board should find all the challenged claims of U.S. Patent No. 10,755,409 (the “’409 patent”) are patentable over the ground raised in the Petition.

Petitioner advances a single obviousness combination, which begins with Salah’s use of a mobile phone to provide real time guidance in the initial acquisition of dental images. Because Salah does not disclose determining the claimed image attribute value to guide image acquisition, however, Petitioner is forced to contend that a POSA would have been motivated to use the guidance technique in Carrier with the method and apparatus of Salah. But that combination still does not suggest using a deep learning device. Thus, Petitioner resorts to arguing that a POSA would have been motivated to use Maninis’s “deep learning architecture” “to detect specific teeth bounded by the detected contours.” Paper 2, 29-30, 34. A POSA would have had no such motivation, though, because Maninis’s COB neural network is *incapable* of performing this task. *In re ICON Health & Fitness, Inc.*, 496 F.3d 1374, 1382 (Fed. Cir. 2007) (“[A] reference teaches away from a combination when using it in that combination would produce an inoperative result.”); *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984). Petitioner’s entire case is thus premised on a fundamental misunderstanding of Maninis’s neural network and should be rejected.

An entirely different neural network would have been necessary to address Petitioner's alleged motivation. Although Maninis refers to such other neural networks, they are described by *different* authors in *different* papers not in evidence in this proceeding. Petitioner cannot rely on that disclosure now. *See* 35 U.S.C. § 312(a)(3); *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369-70 (Fed. Cir. 2016). Petitioner fails to offer any evidence of whether: (1) those other neural networks satisfy the limitations of the challenged claims; (2) a POSA would have been motivated to use those other neural networks in the proposed combination; or (3) whether a POSA would have had a reasonable expectation of success in doing so.

There are yet further independent and critical deficiencies in Petitioner's ground.

First, Petitioner identifies no motivation to use Carrier's alignment technique with Salah's image acquisition method and apparatus. Carrier's image alignment technique does not provide the "same function" as Salah's method for providing real time guidance to the user—Carrier's lacks essential functions of the Salah method Petitioner proposes to replace.

Second, any attempt to use a neural network referenced in Maninis to achieve the *real time guidance* in the initial acquisition of dental images *on a cell phone* in Salah and Carrier would have been unsuccessful. Although not required by claim

1 of the '409 patent, Petitioner's obviousness argument is that a POSA would have been "motivated to adapt Salah and Carrier's image acquisition device to employ a neural network as taught by Maninis." EX1002, ¶86; Paper 2, 23. Thus, the Board must consider whether a POSA would have had the particular motivation advanced by Petitioner. *See, e.g., Intelligent Bio-Sys.*, 821 F.3d at 1368. Here, even if operable, none of the purported advantages of Maninis are beneficial in the context of Carrier or Salah, and a POSA would have recognized that any alleged improvement in contour accuracy would be wiped out by the significant costs and delay associated with implementing Maninis.

Petitioner's arguments as to dependent claims 7-9, and 14 fail for additional reasons. For example, claim 7 requires that each "historical image" in the learning base comprise an "image attribute value" and that "at least one probability relating to said image attribute value" is determined during analysis. But Petitioner has failed to identify any deep learning device that can be trained on images labeled with an "image attribute value." In addition, claim 14 requires that "the analysis image is analyzed and checked in real time." Petitioner offers no evidence regarding how its combination meets the "real time" limitation, referring only to the unmodified operation of Salah and Carrier. When those references are combined with Maninis, however, no real time analysis would be possible.

For at least these reasons, and as discussed further below, Patent Owner respectfully submits that the Board should find all the challenged claims patentable.²

II. Level of Ordinary Skill in the Art

In its Institution Decision, the Board adopted Petitioner’s then-uncontested assertion that a person having ordinary skill in the art (a “POSA”) “would typically have an advanced degree, such as a Masters’ Degree or Ph.D. in computer science, computer engineering, electrical engineering, or a related field, with at least two years of work in computer vision, image analysis, medical imaging, or related areas” and that they “*could* be a member of an interdisciplinary team including persons with backgrounds such as electrical engineering, computer science, optical imaging, and dentistry or orthodontics, and *could* call upon the knowledge of other team members *as appropriate*.” Paper 10, 13.³

Patent Owner’s experts provided a slightly different definition. EX2002, ¶47 (“[A] person of ordinary skill in the relevant field as of July 21, 2017 would have

² On May 16, 2024, claim 12 of the ’409 patent was held invalid as subject-matter ineligible. *Dental Monitoring SAS v. Align Technology, Inc.*, 3:22-cv-07335-WHA, Dkt. 151 (N.D. Cal. May 16, 2024). Patent Owner intends to appeal.

³ All emphases herein are added unless otherwise indicated.

had a bachelor's degree or higher in computer science, bioinformatics, or a related engineering discipline, and several years of work experience relating to the development of machine learning or artificial intelligence models or algorithms. A POSA *would* have also worked as part of a multi-disciplinary team, which *would have included individuals familiar with medical imaging, dental imaging, dentistry, and/or orthodontics.*"); EX2028, ¶¶48-51; EX2030, ¶¶27-30. Although these definitions are not materially different, the definition of a POSA is material to the merits of Petitioner's ground.

Here, the relevant field is dental imaging; both Salah and Carrier concern acquiring dental photographs, and discuss concepts specific to dentistry and orthodontics. EX1002, ¶81; EX2030, ¶¶25, 30; EX2028, ¶51. Patent Owner's Response is thus supported by the Declaration of Dr. Budi Kusnoto—a practicing clinician, researcher, and academic in orthodontics for twenty-five years—with whom Dr. Mongan consulted in forming his opinions on the '409 patent. EX2028, ¶51; EX2030, ¶¶2-11.

As Petitioner's definition recognizes, a POSA "*could* call upon the knowledge of other team members *as appropriate.*" Paper 2, 14-15. For Salah and Carrier, it would have been appropriate, and in fact necessary, for a POSA to consult with an individual having experience in dentistry and/or orthodontics to understand their teachings. EX2030, ¶¶26, 30, 76; EX2028, ¶51.

However, Petitioner’s expert, Dr. Foroosh, has no professional training or experience with dentistry or orthodontics, and admitted he did not consult with such a person in forming his opinions. EX2048, 11:9-11; 12:19-22; 13:12-23. Although he once had an industrial engagement to analyze dental images (not with neural networks), the company leading the project also engaged dental experts, with whom Dr. Foroosh had no contact. *Id.*, 19:20-20:11. Dr. Foroosh’s lack of relevant experience led him to misinterpret Carrier and Salah. For example, because Dr. Foroosh has no understanding of the “orthodontic standards” for acquiring dental photographs, nor why they might have been required, he reads into Carrier a “tooth counting” alignment technique that is never disclosed. *Id.*, 129:3-130:11; EX1006, [0004]; EX1005, [0004]; *infra* §VII.D.

“[T]he level of ordinary skill in the art is ‘a prism or lens through which ... the Board views the prior art and the claimed invention’ to prevent hindsight bias.” Paper 10 at 13 (quoting *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001)). Because Petitioner failed to consider the ground references from the perspective of a properly informed POSA under either definition, its hindsight-driven grounds should be rejected.

III. State of the Art

A. Dental Photography

For decades before the '409 patent, dental photographs captured by dental professionals during in-office patient consultations were an integral part of dental care. EX2030, ¶¶32-34. By 2017, there was a recognized standard set of orthodontic photographs comprising the following specific views of a patient's teeth:



EX2030, ¶¶32-33 (showing: three head shots (top row); occlusal maxillary (top) view (middle row, left); occlusal mandibular (bottom) view (middle row, right); right buccal view (bottom row, left); frontal view (bottom row, center); and left buccal (bottom row, right)); EX2033; EX2038.

The goal was to capture each of the views necessary for maintaining patient records and to perform qualitative assessments of a patient's teeth for clinical

purposes. EX2030, ¶¶43-44; EX2047; EX2046, 459-461. The standard views were agnostic to the details of the individual patient's mouth and were not patient-specific—the same set of photographs would be captured no matter the patient's dental situation.



Figure 8 Right Buccal View - In Occlusion.



Figure 9 Left Buccal View - In Occlusion.

EX2040, 29 (showing standard buccal views, despite unique features of the patient's teeth); EX2030, ¶34.

Acquiring standard orthodontic images required specialized training and equipment, *e.g.*, cheek retractors, dental mirrors, and a DSLR camera. EX2040, 23-25, 28-31; EX2034; EX2035; EX1008, Figs. 5A-5B; EX1006, [0051], Figs. 1A, 9; EX2034, 21; EX2037, 4; EX2030, ¶¶35-42. Although some dentists had attempted to use cell phones, this was rare due to associated challenges. EX2030, ¶¶23, 40. For example, holding the phone “close to the teeth” to get a “high level of detail,” could result in “blurry” images and “optical distortion.” EX1006, [0004]; EX2030 ¶¶40, 54. But holding the phone “too far” from the teeth, resulted in a different

problem—photos that “cannot meet the orthodontic standards.” EX1006, [0004]; EX2030, ¶¶40, 54.

As of July 2017, artificial intelligence (*e.g.*, machine learning or deep learning) was not used in acquiring dental photographs. EX2030, ¶¶23, 45; EX3037, ¶34 (conceding that deep learning was not part of the standard of care in 2017). At that time, dental professionals were very cautious of new technologies because of the potential impact on patient outcomes. EX2030, ¶45; EX2036, 50:3-5, 50:19-24.

B. Neural Networks

In the context of image recognition, as of July 21, 2017, it was known that neural networks are algorithms that had been trained to evaluate certain images and output probabilities associated with attributes they had been trained to recognize. EX2028, ¶¶125-30. A POSA would have understood, however, that neural networks are not general-purpose tools. *Id.* Instead, they are useful only after they have been trained, and recognize only what they have been trained to recognize. *Id.* In other words, it was known that each neural network trained for an image recognition task is unique to the annotated images on which it has been trained, and its success depends on the quality of that training and the challenge(s) of the attributes the neural network is tasked with recognizing. *Id.* In his declaration, Dr. Mongan—a professor in the Department of Radiology and Biomedical Imaging at University of California San Francisco, who has been involved with machine

learning, deep learning, and neural networks for his entire career—describes a simple example of training a neural network. *Id.*, ¶¶126-30. A POSA would have recognized that neural networks—including those discussed in Maninis—could be much more complex. *Id.*, ¶130.

IV. Overview of the '409 Patent

The '409 patent claims priority to July 21, 2017. Petitioner does not challenge this priority date.

The challenged claims provide new and improved methods that employ a “deep learning device” to acquire and analyze dental images. *See, e.g.*, EX1001, 1:22-28, 18:56-61, 28:44-48; EX2028, ¶¶52-66. The deep learning devices are specifically trained for this purpose, using a “learning base” that may comprise “more than 1000” to “more than 100,000” historical images of a patient’s dental arch annotated with information that the deep learning device is to identify in its analysis. *Id.*, 3:13-17, 15:65-16:12. “Through its training..., the deep learning device is capable of analyzing the analysis image and of recognizing said patterns therein.” *Id.*, 16:44-55, 17:37-39, 24:38-59.

The patent discloses two distinct types of analysis the deep learning device can be trained to perform.

In the “**detailed analysis**” approach (or “Analysis by Tooth”), the deep learning device is trained on historical images labeled with “tooth zones”

representing the individual teeth that have been assigned values for a “**tooth attribute**.” *Id.*, 15:28-33. Tooth attributes can, for example, be “tooth numbers,” “a tooth appearance parameter” like “abraded” or “broken,” or a “tooth shape parameter” such as “tooth width” or “crown height.” *Id.*, 8:9-21; 16:44-17:15; *id.*, 1:29-62, 15:34-17:15. The deep learning device trained in this way can recognize the specific tooth attribute on which it was trained in the individual teeth in the analysis image. *Id.*, 16:23-17:15. This “detailed analysis” method “advantageously allows for a fine analysis of the analysis image,” and the “tooth attribute value” also “may be used to define a value for an image attribute” relating to the whole image. *Id.*, 3:19-27, 59-60.

In the “**global analysis**” approach, the learning base contains “historical images whose description provides a global attribute value for the image” called an “**image attribute**” (*i.e.*, “not ... a ‘tooth’ attribute”). *Id.*, 3:19-58; *id.* 15:28-33. When analyzing images, this approach “is similar to the detailed analysis method,” “apart from the fact that ... it is not necessary to analyze the individual situation of each tooth. In other words, the deep learning device determines the value of an ‘image’ attribute without having to previously determine tooth attribute values.” *Id.*, 17:16-26. For example, an “image attribute” could “specify the position of the tongue (for example ‘retracted’) or the opening of the mouth of the patient (for example mouth open or closed).” *Id.*, 3:29-58. Accordingly, the “global image

analysis method ... advantageously makes it possible to immediately and globally assess the content of the analysis image.” *Id.*, 4:33-36.

Thanks to these technological improvements, the patent claims a new and improved method of “embedded monitoring” for the acquisition of dental images that ensures the image meets certain acquisition conditions—which ultimately is necessary for effective dental treatment. *See, e.g., id.*, 23:46-24:8, 24:9-32, 25:13-20. For instance, by specifically determining whether the quality or another characteristic of an acquired image (*e.g.*, “opening of the mouth” or “wearing of a dental appliance”) meets a particular “setpoint” for such an image, requiring adjustments if that “setpoint” is not met, and “guid[ing]” an operator to make the correct adjustments. *Id.*, 27:16-22, 28:44-48, 32:13-33. As another example, the analysis can determine the general orientation of a photograph (*e.g.*, “left photo” or “right photo”) and determine whether that orientation complies with how the operator was instructed to acquire the image. *E.g., id.* 26:9-26.

Although the patent contemplates the identification of analysis tooth zones (*e.g.*, tooth contours), a POSA would have recognized that a particular advantage of applying a deep learning device as described in the patent is the ability to identify complex and wholistic attributes of the teeth or the image, such as “the position of the tongue (for example “retracted”) or the opening of the mouth of the patient (for example mouth open or closed) or the presence of a representation of a dental,

preferably orthodontic, appliance and/or of its condition (for example appliance intact, broken or damaged).” *E.g., id.*, 3:19-37. An additional advantage of the embedded monitoring approach is that it allows acquiring useful images by patients, who may otherwise make a “mistake in the acquisition of the updated images.” *Id.*, 25:34-39.

The patent further discloses that dental images can be annotated with information from a 3D model of the patient’s teeth to produce “historical images” to enrich a learning base, reducing the expense of manually annotating such images. *E.g., id.*, 2:4-3:18, 15:23-33, Figs. 2-3, 5, 17. This method “is particularly effective for creating a learning base” that may be used to train the deep learning device to make an accurate assessment. *See, e.g., id.*, 13:62-63.

V. Claim Construction

In view of the positions taken by Petitioner, as well as the Board’s analysis in the Institution Decision, Patent Owner requests construction of the following terms.

A. “deep learning device” (all claims)

A POSA would have understood that, in the context of the ’409 patent, the term “deep learning device” refers to a device that, through training, is capable of analyzing an image and recognizing patterns therein. EX1001, 16:53-55 (“Through its training ... the deep learning device is capable of analyzing the analysis image

and of recognizing said patterns therein.”); *id.*, 17:37-39, 24:38-59; EX2028 ¶¶150-53. To the extent the Board understood in its Institution Decision that the “device” in “deep learning *device*” refers to a physical device (*e.g.* a processor or computer), that is not how a POSA would have understood that term in the context of the patent. EX2028, ¶151.

The patent discloses that the invention includes “a computer program, and in particular *a dedicated application for cellphones*, comprising program code instructions for the execution of one or more steps of any method according to the invention, when said program is run by a computer.” EX1001, 31:61-67. It further repeatedly states that the “deep learning device” is “preferably a neural network.” *E.g., id.*, 1:22-28, 1:39-40, 1:66-67, 3:14-18, 8:41-43; 13:64-65, 16:14-43. The patent expressly identifies that “[a] ‘neural network’ or ‘artificial neural network’ is a set of algorithms well known to a person of skill[] in the art,” identifying several well-known neural network architectures as examples of “devices” that can be trained to perform the claims. *Id.*, 16:15-43. Petitioner’s expert shares the same understanding. EX2048, 201-04 (confirming a neural network can be described as “an algorithm with values that are updated through the training process” and clarifying that the “layers” in its “architecture” are “not ... hardware”).

The patent thus confirms that the “deep learning device” is preferably an “algorithm,” which is a program written in computer code. Accordingly, a POSA

would have understood that the word “device” in “deep learning device” refers to a computer program or algorithm(s), not to the hardware on which the algorithm runs. EX2028, ¶¶151-53; EX2048, 209:24-210:5 (confirming that, “once ... trained,” neural networks can be “put ... on any number of computers and run[]”).

B. “real time” (claim 14)

Claim 14 recites the limitation “said analysis image is analyzed and checked in real time.” The ’409 patent gives an example of an image being “analyzed and checked ... in real time” where an updated image is analyzed and compared to the acquisition instructions (“updated image has been ‘taken on the right’”) sufficiently quickly to “immediately alert the operator ... to modify the acquisition direction” if the “value of the updated image ... does not correspond to the instruction.” EX1001, 25:50-62. This is the same context as the term is used in claim 14. Accordingly, a POSA would have understood that the term “real time” means the analysis and checking occur “immediately,” while the image acquisition process is still underway. EX2028, ¶¶154-55.

Petitioner’s expert offered no definition for “real time” and confirmed at deposition that he was unable to determine its construction. EX2048, 71:6-73:19. As discussed further below, Petitioner (together with its expert) has failed to meet its burden to prove the unpatentability of claim 14.

C. “tooth shape parameter” (claim 4)

The '409 patent indicates that the term “tooth shape parameter” is one type of “tooth attribute.” EX1001, 8:9-21, cl. 4. Examples of “tooth shape parameters” are “tooth width, ... a thickness, a crown height, ... or a level of abrasion.” *Id.* These “tooth attributes” are associated with but distinct from “tooth zones,” the latter being a “zone representing, at least partially, [a] tooth in [an] image.” *E.g.*, *id.* 1:30-50; 6:30-35; 13:31-46; 16:6-12; 16:44-50.

Petitioner’s expert opines that “tooth shape parameter” encompasses the “contour” of a tooth. However, a “contour” is a set of pixels identified in the image bitmap as bounding an object. *Infra* §VI.C.1. Dr. Foroosh improperly conflates “tooth shape parameter” with “tooth zone,” which he also identifies as the contour of a tooth in an image. Contrary to his assertions, a POSA would have understood that the “tooth attribute,” including a “tooth shape parameter,” describes an **attribute** of the tooth depicted within the boundary of the “tooth zone” (*e.g.*, its width), and it must be capable of association with a tooth zone in a historical image in the learning base for training (*i.e.*, the pixels within the tooth zone would have values indicating that attribute). EX2028, ¶¶156-58. Accordingly, the attribute (tooth shape parameter) cannot be the pixels of the zone itself and Petitioner cannot rely on detecting a tooth boundary or segment as detecting an image attribute value. To the extent Dr. Foroosh is observing that tooth shape attributes, such as width,

can be derived from the image of a tooth (*i.e.* from visual analysis of the pixels in the tooth zone), that does not alleviate the need for the resulting description to be an “attribute” of the tooth rather than the segment itself.

VI. Overview of References

A. Salah

Salah is directed to monitoring the position and/or shape of a patient’s teeth over time. EX1008, 1:25-2:19; EX2028 ¶¶67, 99-102. Salah’s multi-step method includes creating a 3D digital reference model (“initial reference model”), acquiring a 2D image of the patient’s arches (“updated image”), and, via a comparison between the initial reference model and a “final reference model” created from the “updated image,” determining deformation or displacement of teeth between the creation of the reference model and the updated image. *Id.*; EX1008, 1:25-2:19; EX2028, ¶¶67-98; EX2030, ¶¶84-87.

As to image acquisition, Salah is clear—the goal is to enable “image acquisition [to] be carried out by the patient himself or by one of their relatives, using a simple cell phone, anywhere, and especially outside a medical, dental or orthodontic practice.” EX1008, 31:4-7. Salah thus identifies exemplary means of providing guidance to the untrained user such as via “written and/or voice prompts,” including ones that indicate whether the photo should be taken from the “front” or the “right,” by “displaying an arrow to orient the user,” or by indicating

that the photo “is acceptable” or that the user “must take another photo.” EX1008, 27:22-28:2; EX2028, ¶75. A POSA would have understood that such guidance is provided in real time while the user is taking photographs. EX1008, 10:22–26, 54:12–15; EX2028, ¶¶81-84; EX2030, ¶¶93-94; EX1002, ¶228 (“Salah provides real time feedback on alignment[.]”); EX2048, 71:18-23, 79:3-14.

Importantly, Salah’s method merely requires “a simple image of the teeth, taken without precise pre-positioning of the teeth in relation to the image acquisition apparatus ... to accurately assess tooth displacement and/or deformation.” EX1008, 2:21-27. Thus “[t]he person creating the images” need only “position[] the image acquisition apparatus in an *approximate* manner.” EX1008, 31:12-13, 31:26-27. “The ability to acquire images with limited precision is a *considerable advantage*, since it makes acquisition possible anywhere and by anyone.” EX1008, 31:23-24; EX2028 ¶¶74, 85.

To further this goal, Salah describes “verification means” for assisting with alignment of the “updated image.” EX1008, 27:19-30:21; EX2028 ¶¶74, 76-80; EX2030, ¶¶88-89. The “verification means” comprise a “reference,” a visual indicator that appears on patient’s mobile device, such as a “line intended to be aligned with the general direction of the juncture between the upper and lower teeth,” marks representing where the patient’s eyes, mouth, or face are to be positioned on the screen, or a view of patient’s dental arch “in transparent form,”

which “makes it very easy for the patient to superimpose such a view approximately on the teeth to be photographed.” EX1008, 27:19-30:21.

Salah also discloses using “registration marks” that correspond to and can be automatically aligned with the “references” so that images are acquired according to “target acquisition conditions.” EX1008, 28:13-30:21; EX2028, ¶¶78-86; EX2030, ¶90. The “registration marks” can be attached to a dental retractor, and may take the form of shapes, colors, letters, or numbers, and may be of various sizes. EX1008, 28:13-29:17, 30:4-15, 30:22-25; EX2028, ¶78. These “registration marks” also play an important role in the subsequent steps of Salah’s method, increasing speed and efficiency. EX1008, 32:26-33:5, 36:17-38:9; EX2028, ¶¶86, 93-96.

“Preferably, the acquisition apparatus is programmed ... to detect registration marks on the retractor, analyze their relative positions or dimensions and, as a result, inform the user of the device to modify the position of the acquisition apparatus in relation to the patient’s teeth.” EX1008, 54:12-15; *see also id.*, 10:22-26; EX2028, ¶101. Salah further teaches that the software program runs on the image acquisition apparatus itself. EX1008, 10:22-26, 16:13-21, 30:22-31:2, 54:12-15, cls. 4, 7; EX2028, ¶84; EX2030, ¶91. Indeed, Salah states that “[i]n particular, the acquisition apparatus can be a cell phone, and the program can be a specialized cell phone app.” EX1008, 32:1-2.

Salah never suggests automatically—as opposed to manually—aligning an overlay *with the patient’s teeth*. On the contrary, Salah expressly teaches away from using such comparisons to achieve alignment. EX1008, 31:26-27 (“Preferably, no measurements are taken on the teeth to bring the acquisition apparatus into the matching position.”). A POSA would have recognized that, because the patient’s teeth are expected to move and may be in unknown positions when the “updated image” is acquired, the teeth are unsuitable for use as fixed “registration marks” to ensure target acquisition conditions are satisfied. EX2028, ¶¶77, 82; EX2030, ¶92.

B. Carrier

Carrier was filed on November 18, 2020, after the ’409 patent priority date. It is undisputed that Carrier is only prior art to the extent the Carrier Provisional (EX1006) “describes the subject matter” relied upon in Carrier. 35 U.S.C. § 102(d)(2); *Penumbra, Inc. v. RapidPulse, Inc.*, IPR2021-01466, Paper 34 (Mar. 10, 2023). Carrier contains significant matter that was added over the Carrier Provisional (*see* EX2004), but Petitioner can rely only on disclosure present in both Carrier and the Carrier Provisional. EX1002, ¶¶50-51; EX2048, 127:16-23.

1. Overview of the Carrier Provisional

The Carrier Provisional seeks to address certain problems dental professionals faced using cell phones to acquire dental photographs. *Supra* §III.A.

Its solution: an “overlay comprising an outline of teeth in a predetermined view” displayed on the screen of a mobile phone. EX1006, [0006]-[0007]; *see also* EX1006, [0054]; EX1005, [0006]-[0008], [0099]; EX2028, ¶¶111-17; EX2030 ¶¶53-71. The Carrier Provisional instructs dental professionals to move the mobile phone so that the overlay approximately matches the view of the patient’s teeth on the screen to capture a predetermined view. EX1006, [0007]; EX1005, [0008]; EX2028 ¶¶114-17; EX2030 ¶¶64, 68, 70. Those predetermined views correspond to the known “set of dental images according to the orthodontic standards.” EX1006, [0004], [0015], [0029], [0035], Figs. 1A-1C, 4A-4H, 5A, 11A-11H; EX1005, [0004], [0016], [0065], [0071], Figs. 1A-C, 4A-4H, 5A, 11A-11H; EX2028, ¶¶111-12; EX2030, ¶¶53-55, 60-63.

Like Salah, the Carrier Provisional teaches that a high degree of accuracy is not necessary, and instead, “an *approximate* visual match is needed to select the correct distance, correct angle and correct view of the patient’s teeth.” *E.g.*, EX1006, [0060]; *see also id.* [0061], [0063] (alignment when only 50% to 90% of outline is within 0.1 mm to 1 mm of overlay); EX1005, [0105], [0106], [0108]; EX2028, ¶¶114-17; EX2030, ¶¶26, 64, 77-78, 81-82. The Carrier Provisional further discloses that a non-patient-specific overlay can be used, and that it is sufficient to achieve the goal of the Carrier Provisional—capturing standard orthodontic photographs—that the positioning of the patient’s teeth approximately

matches a generic overlay. EX1006, [0060]-[0061]; EX1005, [0105]-[0106]; EX2028, ¶116; EX2030, ¶79.

The Carrier Provisional discloses “automatically triggering an indicator when the overlay approximates matches with the patient’s teeth.” *E.g.*, EX1006, [0010]; EX1005, [0011]. This method can comprise providing real time guidance to the dental professional. For example, the Carrier Provisional discloses “estimating an indicator of the distance between an edge of the patient’s teeth at two or more regions and the outline of teeth and comparing that indicator to a threshold value,” where the indicator “can be a visual indicator, such as a change of color” or “a voice indicator.” *E.g.*, EX1006, [0010]; EX1005, [0011]; EX2028, ¶¶114, 117; EX2030, ¶¶68-70.

A POSA would have recognized that, in this context, a dental professional would not have benefitted from delayed guidance about camera alignment. For example, if the dental professional received a notification to adjust the camera position only after a delay, that guidance would not be helpful in guiding the dental professional (as the Carrier Provisional envisages). *See, e.g.*, EX1006, [0053] (“In general, these method[s] and apparatuses may improve on existing technology **by guiding a user through the process of collecting relevant patient images** (*e.g.*, a predetermined set of images).”); *see also id.*, [0054], [0063]; EX1005, [0098]-[0099], [0108]; EX2028, ¶¶118-19, 192-93; EX2030, ¶¶67-69, 94. Additionally,

if the guidance in the Carrier Provisional were not real time, the dental professional and the patient would have to hold perfectly still while awaiting guidance, or the mobile phone would no longer be in the same place when the guidance arrived. A POSA would have recognized that such a process would not be workable, as it would be very difficult for a dental professional to hold a mobile phone completely stable and for a patient to stay perfectly still. EX2028, ¶194; EX2030, ¶¶69, 94.

As with Salah, the Carrier Provisional uses software “being executed by a processor of a mobile phone.” EX1006, [0019], [0063]; EX1005, [0020], [0108]; EX2028, ¶119; EX2030, ¶68. While the images may subsequently be transmitted to a remote server and evaluated “for medical treatment,” the Carrier Provisional nowhere describes any analysis on such a “remote server” as guiding image capture. EX1006, [0014], [0086]; EX1005, [0015], [0134]; EX2028, ¶119.

The Carrier Provisional also discusses “using image recognition algorithms to ensure that all required teeth are visible.” EX1006, [0081]; EX1005, [0128]. Given the context of standard orthodontic photographs, a POSA would have understood that the “required teeth” are those that are visible when taking a photograph of a specific view. EX2028, ¶113; EX2030, ¶¶36, 64, 76-80. This is consistent with the discussion in the Carrier Provisional: that “[t]he overlay with an outline of teeth in a predetermined view can further provide information such as required visible teeth in the predetermined view” (EX1006, [0060]; EX1005,

[0105]; EX2028, ¶¶112-13, 209; EX2030, ¶¶55, 78-80); and that a generic overlay can be used to capture high quality dental images, even though patients may have different numbers of teeth than shown in the overlay—as illustrated in Figure 2. EX1006, [0032], [0060]-[0062], Figs. 2 C; EX1005, [0068], [0105]-[0107]; EX2028, ¶209; EX2030, ¶¶64, 79-80. A POSA would not have understood either the reference to “image recognition algorithms,” or to “edge detection image processing,” to suggest the use of deep learning in view of its unnecessary complexity for achieving Carrier’s wholistic-contour-based approach. EX2028, ¶¶108, 120, 121-23; EX2030, ¶¶23, 45; EX2044.

2. Under *Dynamic Drinkware*, Petitioner Would Not Be Entitled to Its Alleged Priority Date for Carrier

Under *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1380 (Fed. Cir. 2015), Carrier is only entitled to the priority date of the Carrier Provisional if Petitioner can demonstrate that the Carrier Provisional provides written description support for at least one claim of Carrier. *See Atlas Glob. Techs. LLC v. TP-Link Techs. Co., LTD.*, 2023 WL 5346490, at *4-5 (E.D. Tex. Aug. 1, 2023), *report and recommendation adopted*, 2023 WL 5336934 (E.D. Tex. Aug. 18, 2023) (finding *Dynamic Drinkware* “instructive” for determining priority under AIA § 102(d)). Here, Petitioner contends the Carrier Provisional provides Section 112 support for Carrier claim 1. Paper 2, 9-10; EX1002, ¶¶51-61.

None of Petitioner’s citations to the Carrier Provisional describe a method using “a mobile application on a mobile device associated *with a patient*” or the “guiding *the patient*” limitations of Carrier claim 1. EX2028, ¶¶104-09; EX2030, ¶¶24, 72-75. To the contrary, the relevant POSA concerning Carrier—which Petitioner has not defined—would have understood the Carrier Provisional is directed to methods for *dental professionals* to capture dental images using a mobile device associated with the *dental professional*. See, e.g., EX1006, [0057], [0004], [0051], [0056], [0081], [0095]; EX1005, [0004], [0096], [0101]-[0102], [0128], [0172]; EX2030, ¶¶72-75. For example, the Carrier Provisional cell phone app is clearly directed to dental professionals, presenting a list of patients from which the user can select—something a patient would not have access to. EX1006, [0095]; EX1005, [0172]; EX2028, ¶106; EX2030, ¶75.

Because the Carrier Provisional does not provide §112 support for Carrier claim 1, Carrier is not prior art under *Dynamic Drinkware*. 800 F.3d at 1380.

C. Maninis

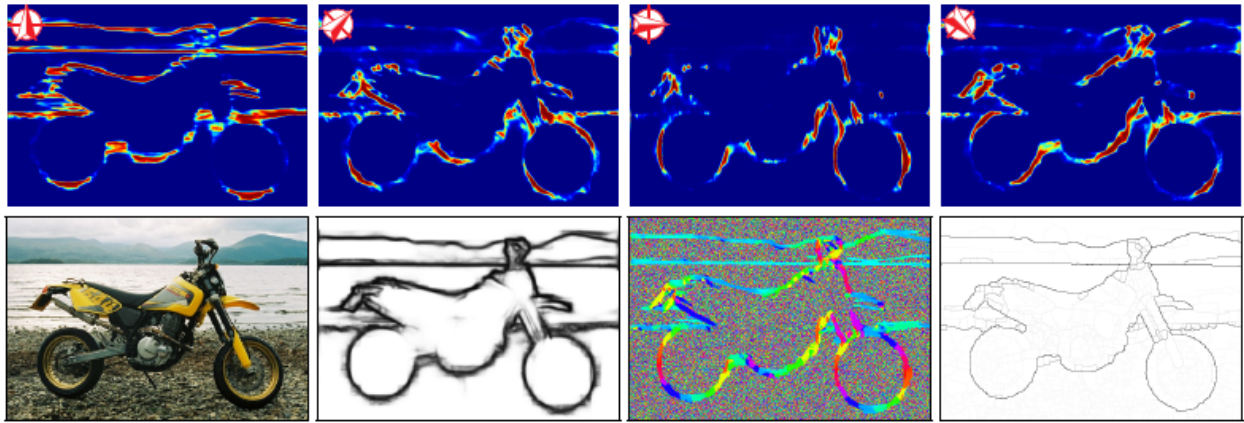
Maninis proposes a technique, to which the authors refer as Convolutional Oriented Boundaries (“COB”), for determining boundaries in an image using a convolutional neural network (“CNN”) (referred to herein as the Maninis “COB neural network”), which can be applied in combination with other neural networks

to determine semantic contours—it contains no reference to the field of dental imaging. EX1007, 1; EX2028, ¶131.

1. Overview of Maninis’s Techniques

In Maninis, the COB neural network is used to identify generic contours.⁴ *Id.* at 1-2. Maninis then uses those contours to form an ultrametric contour map (UCM) that is fused into a hierarchical segmentation. *Id.*, 1-3, 5. This hierarchical segmentation identifies boundaries that belong to the outline of an object (*e.g.*, a motorcycle) or a sub-part of that object (*e.g.*, the black region in the middle of the motorcycle’s seat), as illustrated below:

⁴ As of 2017, a POSA would have understood that “boundaries” or “contours” are the outlines of objects depicted in an image. A POSA would have known that contour (or edge) detection is the process of detecting the location of those contours (or edges) in an image. In practical terms, this means identifying whether each pixel in an image is part of a contour or not. A segment is a region within a contour. “Semantic segmentation” is the labeling of pixels in an image as associated with a particular identified object and “semantic boundaries” are the contours (or edges) that define a particular identified object. EX2028, ¶132.



Id. at 4, Fig. 3 (hierarchical regions depicted in bottom right image); EX2028, ¶¶132-33.

Although Maninis’s COB neural network can identify the contours of objects depicted in images, Maninis discloses clearly that its COB neural network *cannot* determine what object is defined by that boundary. For example, Maninis discloses that its COB neural network achieves “Low Level Applications,” like “generic image segmentation” and “object boundary detection,” neither of which include object recognition or identification. EX2028, ¶¶134-35; EX1007, 7 (In “object boundary detection, “[t]he goal is to detect the boundaries of the objects ... *without distinguishing the semantics.*”), 10.

However, to achieve the “High Level Applications,” including the “semantic segmentation” on which Petitioner relies for its obviousness combination, the Maninis authors expressly indicate that it is necessary to use other techniques—specifically, they use other neural networks (“Dilated Network” and “PSPNet”)

described in other publications by other authors. EX2028, ¶¶136-39; EX1007, 9 (“In Section 6.2 we study the interplay of our boundary detector with semantic contours and semantic segmentation *by combining COB with Dilated Network [68] and PSPNet [69][.]*”), 13 (The Maninis COB neural network was used in “*in combination with*” other neural networks that perform the “high-level vision tasks (object proposals, object detection, and semantic contours and segmentation).”).

This distinction between the capabilities of the different neural networks in Maninis is illustrated by comparing Figures 9 and 10 with Figure 16. EX2028, ¶¶135-37. Figure 9 shows the results of Maninis’s “generic image segmentation” with row 3 depicting the hierarchical boundaries Maninis determined using the results of its COB neural network. EX1007, 7, 9, Fig. 9 (below).

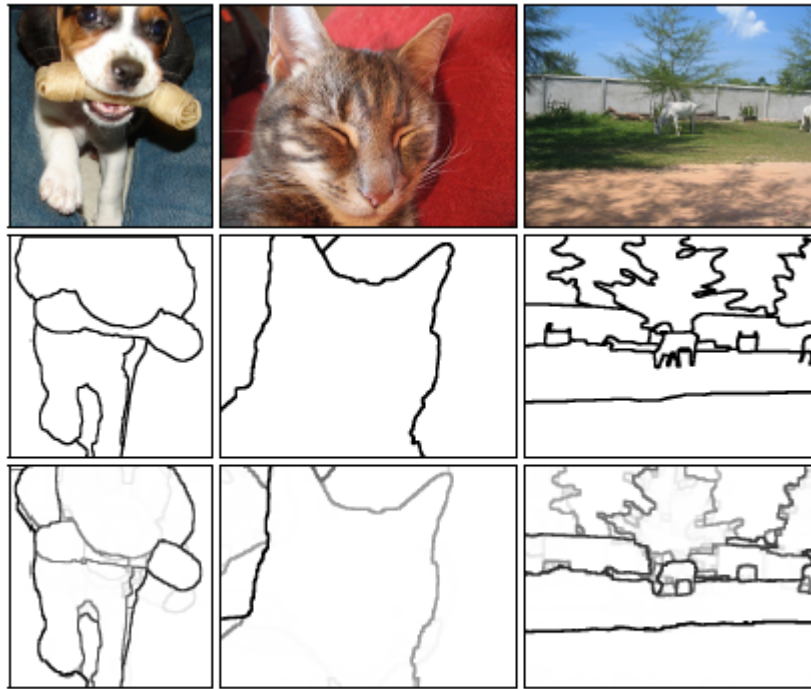


Fig. 9. Qualitative results on PASCAL - Hierarchical Regions. Row 1: original images, Row 2: ground-truth boundaries, Row 3: hierarchical regions with COB.

Although Maninis describes these contours as “semantically meaningful,” a POSA would have recognized that no “semantic segmentation” or object classification was performed by the Maninis COB neural network. EX2028, ¶135; EX1007, 7. Likewise, Figure 10 illustrates “generic segmentation and object boundary detection,” but not semantic segmentation or object identification. EX1007, 7-9, Fig. 10 (below); EX2028, ¶135.

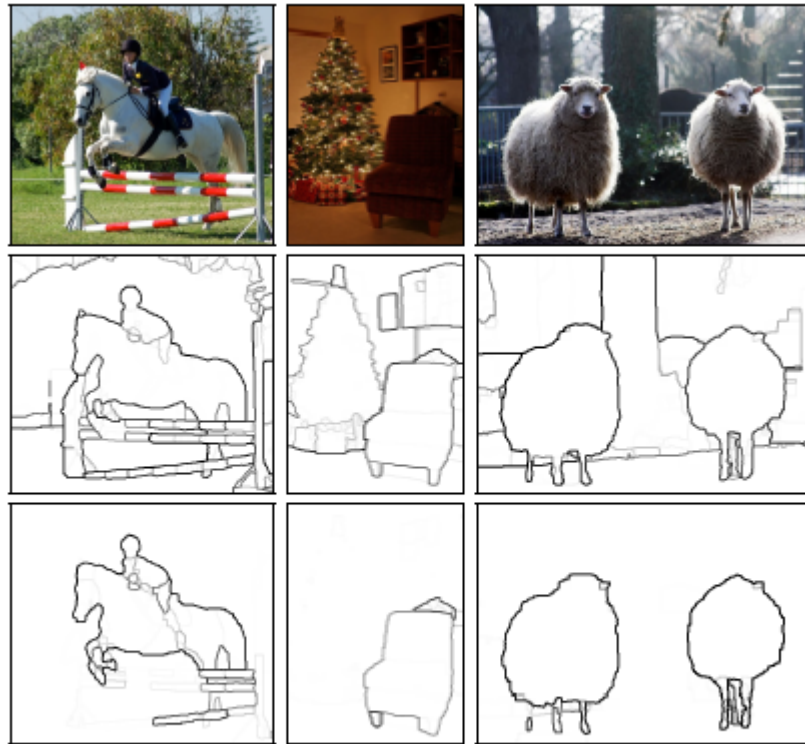


Fig. 10. Qualitative results for Object Boundaries. Row 1: original images, Row 2: Generic Image Segmentation results, Row 3: Object Boundary results.

By contrast, Figure 16 depicts semantic segmentation where each region has a color identifying it as background or as associated with a particular object—e.g., the color green for a train—achieved *only* by using the Maninis COB neural network in combination with one of two other neural networks described elsewhere. EX1007, 9-12, Fig. 16 (below); EX2028, ¶136. The second row shows the semantic segmentations—which are the output of a separate neural network called “Dilated Convolution Network”—and the third row shows how that segmentation was refined with contours produced by the Maninis COB neural network.



Fig. 16. Qualitative results for Semantic Segmentation. Row 1: original images, Row 2: Dilated Convolution Network, Row 3: Dilated Network with COB superpixels.

EX1007, 11-12, Fig. 16; EX2028, ¶136. In other words, the Maninis COB neural network only refined the definition of the segment boundaries; it did not itself identify what was depicted within each segment. EX2028, ¶136.

Thus, to determine “semantic boundaries,” which “requires not only detecting the boundaries, but also associating a semantic class to them,” a POSA would have recognized the need to employ *both* the Maninis COB neural network, which only provides “binary information of boundaries,” *and* a separate neural network capable of semantic segmentation, which “label[s] each of the detected pixels with the corresponding semantic class,” and then “fuse the results of the two tasks.” EX1007, 11; EX2028, ¶137. Maninis similarly discloses in Section 6.3 that

yet another neural network (“Fast-RCNN [70]”) was required for object detection. EX1007, 12-13; EX2028, ¶139.

That the Maninis COB neural network determines only generic boundaries is confirmed by its training. The authors disclose that the Maninis COB neural network training is governed by an equation that mathematically precludes training on semantic contours or object classifications. EX2028, ¶140; EX1007 at 3 (“Equation 1” restricting pixel values to two, binary choices: “0” (not part of a contour) or and “1” (part of a contour)), 4 (“In the rest of the paper we use the class-balancing cross-entropy loss function of Equation 1.”); EX2042, 3. Thus, even though the Maninis authors relied on training databases that include semantic contours and object labels, they “extract[ed the] contours” to the exclusion of the semantics when training the Maninis COB neural network. EX2028, ¶140; EX1007, 7. A POSA would have recognized that, because the Maninis COB neural network is trained only on simple contours, it can recognize only simple contours when analyzing new images. EX2028, ¶140.

Accordingly, when Maninis reports the “Efficiency Analysis” in Section 5.6, including the “Total Time” (0.79 seconds) it took to determine hierarchical regions (“OWT, UCM”) in an image, a POSA would have understood that these times account *only* for generic image segmentation. EX2028, ¶141; EX1007, 9, Table 3. Maninis does not disclose how long it took to determine semantic contours or

recognize objects (*e.g.*, cat, sheep, motorcycle) using the other two neural networks (or using any other neural network). EX2028, ¶141. Indeed, Petitioner has not provided any evidence related to the time it would take to run the Maninis COB neural network together with any of the other techniques Maninis identifies as necessary to achieve semantic contours or object recognition, under any conditions (*e.g.*, with any particular hardware).

Furthermore, Maninis’s analysis time for the COB neural network to determine generic image segmentations was computed “on a NVidia Titan X GPU”—an expensive, state-of-the-art GPU in July 2017 that can perform 11 trillion floating point operations per second (“TFLOPS”) and is designed for large, desktop computers. EX2028, ¶¶142-44; EX2045, 1; EX2005. A POSA would have understood that the capability of graphics cards to handle many calculations simultaneously is critical for running the Maninis COB neural network, which requires billions if not trillions of individual calculations to analyze images. EX2028, ¶142; *cf.* EX1002, ¶31 (“Developments in parallel processing hardware (in particular Graphic Processing Units) made it possible for deep learning networks to be trained in an end-to-end manner and on much larger training sets ... involving tens of thousands to millions of images.”).

As of July 2017, a POSA would have recognized that the Maninis COB neural network was too computationally expensive and resource draining to run on

even the most optimized mobile devices, and it was not suitable for real time contour recognition on devices with power limitations. EX2028, ¶143; *see, e.g.*, EX2006, 1 (“Recent developments in CNN accelerators for system-on-chip integration have reduced energy consumption significantly. Unfortunately, even these highly optimized devices are above the power envelope imposed by mobile and deeply embedded applications.”); EX2007, 2-3.

In 2017, even the most advanced mobile phones—for example, the iPhone 8—had a processing power over an order of magnitude lower (neural engine processing capacity of 0.6 TFLOPS with 2 GB of memory) than the TITAN X GPU. EX2028, ¶144; *see* EX2043, 5-6 (identifying FLOPS for iPhone 8, launched in September 2017). Petitioner has not explained how a POSA would have adapted the Maninis COB neural network to run on the Salah or Carrier acquisition apparatus, *i.e.*, on a mobile phone. A POSA would have recognized that, if Maninis’s COB neural network was run on a mobile phone available in 2017, a conservative, back of the envelope calculation indicates that it would take more than 6 seconds per image to calculate a generic image segmentation (assuming 100% utilization of the “neural engine” processing power). EX2028, ¶144. It would take longer—likely, significantly longer—to apply a second neural network to determine the semantic contours on which Petitioner’s combination depends, and to process the multiple images needed for dental treatment.

2. Petitioner Has Not Demonstrated That Maninis Is Prior Art

To qualify as a printed publication, a reference “must have been sufficiently accessible to the public interested in the art.” *In re Cronyn*, 890 F.2d 1158, 1160 (Fed. Cir. 1989). “Because there are many ways in which a reference may be disseminated to the interested public, ‘public accessibility’ has been called the touchstone in determining whether a reference constitutes a ‘printed publication’ bar under 35 U.S.C. § 102(b).” *In re Hall*, 781 F.2d 897, 898 (Fed. Cir. 1986). Whether a reference is publicly accessible is determined on a case-by-case basis from the “facts and circumstances surrounding the reference’s disclosure to members of the public.” *In re Klopfenstein*, 380 F.3d 1345, 1349 (Fed. Cir. 2004).

Maninis was downloaded by Petitioner from the website arXiv.org. EX1002, ¶62. It bears a stamp indicating it was *submitted*, but not *published* or otherwise available to a POSA, on April 28, 2017. EX1007, 1; EX1002, ¶64; EX2048, 236:17-24. Petitioner has not identified the date on which it was published but offers two pieces of circumstantial evidence to suggest that it was published sometime between April 28, 2017 and the July 21, 2017 priority date of the ’409 patent. Neither suffices.

First, Petitioner cites what it contends are archived copies of the arXiv.org website from 2016 and 2017 reflecting the “policy” of arXiv.org to endeavor to publish articles shortly after they are submitted. EX1022; EX1023; EX1026;

EX1002, ¶¶63-66. Petitioner offers only this unauthenticated hearsay without any testimony from an individual with personal knowledge of either those policies or how the Maninis paper was handled. EX2048, 231:2-234:24. Submissions are subject to review prior to publication, but Petitioner identifies no evidence regarding the timing of any review of Maninis. *Id.*, 232:1-15. Petitioner's expert's anecdotal suggestion that his own papers were published quickly is unsupported and unhelpful. EX1002, ¶63.

Second, Petitioner cites an archived copy of the author's institutional web page prior to July 21, 2017, which links to the arXiv.org URL for Maninis. EX1024; EX1002, ¶67. However, there was an *earlier* version of Maninis, on which Petitioner does not rely in this IPR. EX1002, ¶62. Both versions of Maninis's paper share the same URL, so the existence of a link to that URL suggests only that *one* of the two versions had published as of the archived date—*i.e.* the first version. EX2048, 235:5-236:8.

With less than three months between the Maninis submission date and the '409 patent priority date, it is not trivial that Petitioner offered no evidence of a publication date for Maninis—a reference Petitioner relies on as disclosing several limitations of each challenged claim. Because Petitioner has not met its burden to establish Maninis is prior art, Petitioner's validity challenge should be rejected as to all claims. *See, e.g., Hulu, LLC v. Sound View Innovations, LLC*, IPR2018-

01039, Paper 29 at 13 (PTAB Dec. 20, 2019) (precedential); *see also Louisiana Pac. Group v. Huber Engineered Woods LLC*, IPR2020-00600, Paper 14 (PTAB Aug. 20, 2020) (Petitioner failed to meet its burden when it did not include archived web pages showing publication before the priority date).

VII. Petitioner’s Proposed Combination Is Fatally Flawed

A. Petitioner’s Proposed Combination

Petitioner contends that a POSA would have begun with Salah’s use of a mobile phone to provide real time guidance in the acquisition of dental images. EX1002, ¶¶47, 77. Recognizing that Salah does not disclose determining image attributes values to guide image acquisition, let alone with a “deep learning device,” Petitioner contends that a POSA would have been motivated to use the guidance technique in Carrier with the method and apparatus in Salah. EX1002, ¶¶78-82; EX2028, ¶¶161-62.

Petitioner alleges that Carrier discloses two, related alignment techniques. EX2028, ¶162. The first technique uses an on-screen overlay that assesses alignment by checking whether identified contours of the patient’s teeth are within a threshold distance of the overlay (referred to herein as the “overlay technique”). EX1002, ¶79. For the second technique, Dr. Foroosh reads Carrier’s reference to “ensur[ing] that all required teeth are visible” as indicating that an “image recognition algorithm” should be used to identify which teeth—by number—are

present in an image (referred to herein as the “tooth counting technique”). EX1002, ¶¶80-82, 86, 115, 119-120. As discussed below, both are evaluated simultaneously in the proposed combination.

In further recognition that neither Carrier nor Salah discloses using a deep learning device trained by means of a learning base for analyzing images for guiding the user to acquire images, Petitioner contends that “a POSA would have been motivated to analyze images using a deep learning device as taught by Maninis to improve an image acquisition apparatus as taught by Salah and Carrier.” Paper 2, 23; EX1002, ¶¶83-86 (alleging that “a POSA would be motivated to adapt Salah and Carrier’s image acquisition device to employ a neural network as taught by Maninis” and discussing the alleged specific functionalities provided by “Maninis’s neural network”); EX2028, ¶164. Specifically, Dr. Foroosh asserts that the Maninis COB neural network would be used to determine semantic contours in images of a patient’s teeth, thus providing the contours necessary to apply the “overlay technique” and an identification of each visible tooth to apply the “tooth counting technique.” EX1002, ¶86; EX2048, 53:4-17 (“The combination I am providing with Maninis is actually making them category specific. We do not just identify contours. We are also identifying ... to which tooth a contour belongs to.”), 214:20-215:6 (confirming that in his combination, the deep learning device determines semantic boundaries).

To train the Maninis COB neural network, Dr. Foroosh proposes that the learning base would comprise more than 10,000 dental images, captured by cell phone, similar in composition to the images that would need to be analyzed when carrying out his Salah/Carrier combination. EX1002, ¶167; EX2048, 103:23-106:5, 222:7-12 (same proposed learning base applies to all claims); EX2028, ¶¶165-67. According to Dr. Foroosh, each image would be labeled with pixel-wise contours corresponding to each tooth visible in the image and identified as being associated with the particular tooth (*e.g.*, by tooth number) that it borders. EX1002, ¶151; EX2048, 100:6-12.

Neither the Petition, nor Dr. Foroosh's declaration, identifies a proposed obviousness combination in which the deep learning device is trained on a learning base or performs an analysis different from the above.

B. Petitioner's Obviousness Case Is Incompatible With the Maninis COB Neural Network

Petitioner's obviousness arguments rely on the Maninis COB neural network being trained on a learning base comprising historical images with semantic contours (*i.e.* the contours of individual teeth labeled with the tooth they represent), and as analyzing images to determine the same. *Supra* §VII.A. The Maninis COB neural network is, however, incapable of being trained in such a way or performing such an analysis. *Supra* §VI.C.1. Because this functionality is critical to

Petitioner's obviousness combination for each challenged claim, Petitioner arguments fails across the board and should be rejected.

The source of this shortcoming is Dr. Foroosh's fundamental misunderstanding of the Maninis COB neural network. When asked about the Maninis COB neural network in his deposition, he was confident that it always produces semantic contours or semantic boundaries, even when deployed alone:

Q: And you understand that the results reported in Table 3 for the 0.79 seconds is a determination of hierarchal contours, but not object recognition?

A: No, that's not true. ... the way it happens is not sequential. You know, **the neural network is providing category-specific contours. So what that means is that if -- if it's providing a contour of a cat, it's labeled as a cat that's contoured.** So it's—simultaneously, we know where the cat is in the image.

Q: I see. Okay. So, just to confirm, it's—it's your understanding that when Maninis is discussing the low-level applications in Section 5, that **while it's producing the contours or boundaries, it is also identifying those contours or boundaries as associated with a particular object?**

A: **Absolutely, definitely.**

EX2048, 211-212:15; *see also id.* 216:4-22 (indicating his misunderstanding that Fast-RCNN is not necessary for object detection as described in Maninis Section 6.3). This is incorrect. *Supra* §VI.C.1. (demonstrating that the Maninis COB

neural network is incapable of determining semantic contours or segmentations and object detection). The Maninis COB neural network is capable of being trained *only* on contours, and is capable of identifying in an image *only* contours. Although those contours are aggregated into hierarchies (“UCM”) to identify regions (“segments”) depicting objects that are likely the subject of the image, the Maninis COB neural network is incapable of determining *what those objects might be*. EX2028, ¶¶168-71. In other words, the Maninis COB neural network can detect *the contour* of a cat in an image, but it has no way to determine that what it contoured *is* a cat (as opposed to a train, a person, a motorcycle, or anything else). As Maninis itself expressly discloses, other neural networks are required to make that kind of “semantic” determination.

Although Maninis refers to such *other* neural networks, which are described by *different* authors in *different* papers *not in evidence* in this proceeding, Petitioner cannot rely on that disclosure now. *See* 35 U.S.C. § 312(a)(3); U.S. Patent Trial and Appeal Board, Consolidated Trial Practice Guide 73 (Nov. 2019) (A petitioner “may not submit new evidence or argument in reply that it could have presented earlier, *e.g.* to make out a prima facie case of unpatentability.”); *Intelligent Bio-Sys.*, 821 F.3d at 1369-70. The Petition contains no evidence of whether: (1) those other neural networks satisfy the limitations of the claims; (2) a POSA would have been motivated to use those other neural

networks in the proposed combination; and (3) a POSA would have a reasonable expectation of success in doing so.

To the extent Petitioner now proposes that a POSA would have used those networks *in addition* to the Maninis COB neural network—something never suggested in the Petition—Petitioner has additionally failed to offer any evidence regarding the motivations and expectations a POSA would have had in working with *two* neural networks, or which neural network Petitioner relies on to satisfy a particular claim limitations, many of which are functionally connected within the independent claim and throughout the dependent claims (*e.g.* which “deep learning device” is “trained” by means of which “learning base” and performs which “analysis” to obtain which “results”). EX2028, ¶172.

Petitioner cannot rely on Maninis COB neural network’s detection of generic contours as satisfying either an image attribute value (including for claims 2-6, 10) or an image attribute value (for any claim). *Supra* §V.C.; *infra* §VII.E. To the extent Petitioner nonetheless maintains that Maninis functions within its proposed obviousness combination, Patent Owner addresses additional, critical deficiencies in Petitioner’s ground below.

VIII. Petitioner Has Failed to Prove That the Ground References Render the Challenged Claims Obvious

The burden is on Petitioner to show that a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention and that would have had a reasonable expectation of success in doing so. *Pfizer, Inc. v. Apotex, Inc.*, 480 F.3d 1348, 1361 (Fed. Cir. 2007). This inquiry concerns “whether a skilled artisan not only *could* have made but *would* have been motivated to make the combinations or modifications of prior art to arrive at the claimed invention.” *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015). The mere fact that a possible arrangement existed in the prior art does not provide a reason that a skilled artisan would have attempted such an arrangement. *Virtek Vision Int’l ULC v. Assembly Guidance Sys., Inc.*, 97 F.4th 882, 887 (Fed. Cir. 2024). Here, Petitioner has failed to identify why a POSA would have made the specific asserted combination, and instead relies on the type of hindsight *KSR* warned against. *See KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

A. Petitioner’s Expert Repeatedly Admitted to Relying on Hindsight

At deposition, Dr Foroosh repeatedly and expressly indicated his alleged motivation was improperly guided by an effort to arrive at the ’409 patent claims.

Q: Okay. In your combination of Salah, Carrier, and Maninis, is the person of skill going to practice the aspects of Salah that involve creating a 3D model of a patient's teeth?

A: He may do, yes.

Q: Will they do so? Is that part of what they're motivated to do?

A: Well, I mean, ***the motivation is to combine these three to come up with '409 patent.*** And if it requires that, yes, they would do.

EX2048, 44:18-22; *id.*, 62:3-16 (“Q: ... I’m trying to figure out whether you have considered what a [POSA] would be motivated to do with respect to where the analysis is performed.... A: I have considered that a person of skill would be motivated to use Salah and Carrier, to combine them to come up with the same as the '409 patent.”), 67:18-25, 109:2-19. Dr. Foroosh’s failure to consider the details and consequences of his proposed combination—focusing only on whether the combination would, in his opinion, meet the claim limitations—demonstrates that his analysis is infected by a predetermined desire to arrive at the claim limitations. *Id.*

This is impermissible hindsight. *InTouch Techs., Inc. v. VGO Commc’ns, Inc.*, 751 F.3d 1327, 1349 (Fed. Cir. 2014) (holding it is improper to combine references without “explain[ing] what reason or motivation [a POSA] at the time of the invention would have had to place these pieces together”); *Otsuka Pharm. Co., v. Sandoz, Inc.*, 678 F.3d 1280, 1296 (Fed. Cir. 2012).

Dr. Foroosh's opinions should accordingly be afforded little weight. *Fox Factory, Inc., v. SRAM, LLC*, IPR2016-01876, Paper 59 at 18 (P.T.A.B. April 2, 2018) (giving "little weight to [expert's] testimony on rationale to combine" where motivated by hindsight).

B. A POSA Would Not Have Been Motivated to Combine Carrier's Alignment Technique With Salah's Image Acquisition Method and Apparatus

Petitioner contends that "[a] POSA would have had reason to use Carrier's technique for assessing alignment of teeth to guide users *in an image acquisition apparatus as taught by Salah*. ... Carrier's techniques for assessing alignment would be used *to determine the feedback* to Salah's users *when guiding them to acquire dental images*[" EX1002, ¶¶81-82; Paper 2, 21. However, not only has Petitioner identified no motivation to use Carrier's alignment technique with Salah's image acquisition process and apparatus, but there are several reasons why a POSA would have been discouraged from doing so. EX2028, ¶¶173-81.

Petitioner's expert alleges only that Salah and Carrier are "directed toward the same field of endeavor, namely dental imaging" and "provide complementary teachings regarding the same subject within that field: namely obtaining dentition images with users' mobile phones." EX1002, ¶81. He does not identify any deficiency in Salah's existing technique or any advantage that Carrier's technique might provide. On the contrary, Dr. Foroosh opines that "[i]n combination, Salah's

and Carrier’s teachings would each perform *substantially the same function* as they provide alone.” *Id.*, ¶82. That is incorrect. Carrier’s technique does *not* provide the “same function” as Salah’s—Carrier’s is significantly worse, and its adoption would have been detrimental to the operation of Salah.

Salah already provides a method for automatically aligning a mobile phone to acquire dental images—one that uses “registration marks” added to the retractors. *Supra* §VI.A. A POSA would have understood that those marks not only provide real time guidance of the mobile device during image acquisition but also fulfill other important roles in Salah’s methods. *Id.*; EX2028, ¶¶78-79, 95. Carrier’s alignment technique that uses the patient’s teeth does not offer any of those same advantages. EX2028, ¶178.

Salah’s registration marks have a known size, orientation, and optical character. As a result, Salah uses them to determine where the acquisition apparatus should be in relation to the patient’s teeth to meet the “target acquisition conditions,” to “enable the updated images to be cropped,” and to determine “approximate virtual acquisition conditions approaching the actual acquisition conditions..., which allows data processing to be accelerated.” EX1008, 29:18-23,

32:25-33:5.⁵ Unlike registration marks, patients' teeth have significant variability and move over time, particularly during treatment. EX2030, ¶¶49, 92. This makes teeth unsuitable to substitute for Salah's registration marks. *Id.*; EX2028, ¶179. Indeed, a POSA would have recognized that Salah discourages alignment techniques like those disclosed in Carrier for that very reason. EX1008, 31:26-27 (*"Preferably, no measurements are taken on the teeth to bring the acquisition apparatus into the matching position."*); EX2028, ¶179; EX2030, ¶92.

Furthermore, a POSA would have recognized it would be computationally more challenging to measure alignment with teeth, rather than with a standardized, geometric mark or symbol. EX2028, ¶179; EX1008, 12:6-16, 28:27-29:2. For this

⁵ Although the challenged claims do not require post-acquisition imaging processing, Petitioner's argument is that a POSA would have been motivated to use Carrier's alignment technique in Salah's methods and apparatus. *Supra* §. Accordingly, when evaluating this alleged motivation, the Board should consider the negative impacts that such a modification would have on Salah's methods of monitoring the positioning, shape, and/or appearance of a patient's teeth. *See, e.g., Intelligent Bio-Sys.*, 821 F.3d at 1368 (finding that the shortcomings of a combination are relevant to motivation to combine even when they are not related to claim language).

reason also, a POSA would not have been motivated to abandon Salah's approach, and the multiple benefits it offers, in favor of Carrier's alignment technique as Petitioner proposes. EX2028, ¶180; EX2030 ¶95; EX2048, 178:2-23, 182:7-183:4 (confirming "registration marks" and the corresponding "references" are not used in his proposed combination).

To the extent Petitioner proposes that Salah's and Carrier's alignment techniques would be deployed together, that argument makes no sense. Salah and Carrier require only approximate alignment to achieve their goals—not redundant alignment techniques running in parallel. EX2028, ¶181; EX2030 ¶95; EX1008, 31:23-25 (disclosing that Salah's "ability to acquire images with *limited precision* is a considerable advantage"). Their methods are also designed to use mobile phones, which have limited processing and battery power. A POSA would have recognized that adding a second alignment technique would waste computational resources without providing any operational advantage. EX2028, ¶181; EX1008, 10:22-26, 54:12-15; EX1006, [0019], [0063], [0088]-[0089]; EX1005, [0020], [0108], [0165]-[0166]. Not to mention that having two competing alignment techniques would have confused the user.

Petitioner accordingly fails to meet its burden to show a motivation "to use Carrier's technique for assessing alignment of teeth to guide users *in an image acquisition apparatus as taught by Salah.*" See, e.g., *Belden*, 805 F.3d at 1073

(holding obviousness concerns whether a skilled artisan not only *could* but *would* have made the combination of prior art).

C. A POSA Would Not Have Been Motivated to Combine Maninis with Salah and/or Carrier

Even if a POSA were to combine Carrier’s alignment techniques with Salah—they would not—there would additionally be no motivation to further combine Salah and Carrier with Maninis’s COB neural network (or any other neural network in Maninis). Petitioner does not identify any problem or shortcoming with Salah’s or Carrier’s image acquisition methods that a POSA would have been motivated to try to address by combining these references. Nor has Petitioner identified any advantage to doing so. EX2028 ¶¶182-84. Assuming the Maninis COB neural network could function as proposed (*see supra* §VII.), the combination would not be fit-for-purpose and is fraught with disadvantages that would overwhelm any conceivable benefit.

1. No Benefit Offered by Maninis Applies in the Context of the Proposed Combination

Neither Carrier nor Salah provides any motivation for the combination with Maninis. Petitioner suggests Carrier “expressly invites” the incorporation of Maninis but cites only Carrier’s boilerplate statement that “any *appropriate* technique (e.g., edge detection image processing, etc.)” may be employed. EX1002, ¶84; EX1006, [0063]. But as explained further below, Maninis is not

“appropriate” for Carrier’s alignment technique that provides real time feedback on a mobile device. *Infra* §VII.C.2.; EX2028 ¶185.

Similarly, Salah’s reference to “deep learning”—as a “not preferred” method following more than a dozen “preferred” techniques for determining discriminant information—would not have motivated a POSA to apply Maninis. EX2028, ¶97, 186-87; EX1008, 34:15-36:14. Salah’s disclosure of “deep learning” is exclusively in the context of analyzing images post-acquisition to update a 3D model. Salah never suggests deep learning could or should be used *for determining contours*, and particularly not to guide image acquisition. To the contrary, Salah expressly teaches a “measurement ... taken on the teeth” (*e.g.*, using tooth contours) is “[p]referably” avoided in the context of “bringing the acquisition apparatus into the matching position.” EX1008, 31:12–13, 31:26–27; EX2028, ¶¶186-87.

Nonetheless, Petitioner proposes that “[a] POSA would view Maninis as providing good reasons to employ deep learning techniques for object and contour detection,” but never identifies a “good reason” that would apply to its proposed combination. EX1002, ¶85.

Any “improvements” Maninis offers in speed over state-of-the-art deep learning techniques are irrelevant in view of Petitioner’s misapprehension of Maninis. EX1002, ¶85. Maninis reports speeds only for the COB neural network, not the other neural networks that Petitioner’s combination would require for object

and image classification. EX2028, ¶189. Petitioner offers no evidence that there is any advantage offered by those *other* neural networks.

Likewise, Petitioner offers no evidence any “improvements” in the accuracy of contour detection would translate into an “improvement” in the accuracy of image alignment, nor any “improvement” in the functioning of Salah and Carrier—both of which teach that image alignment need only be approximate. *Supra* §§VI.A.-B. Regardless, a POSA would have recognized that any potential benefit to contour accuracy would be wiped out by the loss of Salah’s existing “registration mark” technique and the significant costs, delay, and incompatibility addressed further below. EX2028, ¶190.

Finally, Maninis’s disclosure that its COB neural network “is compatible with different CNNs” and “is applicable in a ‘modular’ fashion” only indicates that it can be used in connection with *other neural networks*. EX1002, ¶85. A POSA also would have recognized that Manini’s ability to “incorporate and benefit from *future* improvements in the base CNN” is speculative and of no motivational value where Maninis offers no benefits as of July 21, 2017. *Id.*; EX2028 ¶188.

2. A POSA Would Not Have Used Maninis’s Techniques for Carrier’s Real Time Alignment Techniques Using Salah’s Acquisition Apparatus

Significantly, Petitioner fails to address whether a POSA would have had “good reason” to employ deep learning techniques to perform *real time* analyses

on a *mobile phone*. Although not required by claim 1 of the '409 patent, Petitioner's and its expert's entire obviousness case is that "a POSA would be motivated to ***adapt Salah and Carrier's image acquisition device*** [*i.e.*, a mobile phone that provides real time guidance during image acquisition] to employ a neural network as taught by Maninis." EX1002, ¶86; Paper 2, 23 (alleging "a POSA would have been motivated to analyze images using a deep learning device as taught by Maninis to ***improve an image acquisition apparatus as taught by Salah and Carrier***"); EX2048, 56:10-15, 68:25-69:8 (confirming that, in his proposed combination as to each challenged claim, the acquisition device is a mobile device and the analysis image is analyzed and checked in real time).

Accordingly, the Board must consider whether a POSA would have had the motivation advanced by Petitioner, even if the shortcomings in Petitioner's obviousness combination do not relate to the language of all challenged claims. *See, e.g., Intelligent Bio-Sys.*, 821 F.3d at 1368. Further, a motivation to combine analysis ***must*** account for "reasons not to combine" in the context of the prior art, not the challenged claims. *See, e.g., Arctic Cat Inc. v. Bombardier Rec. Prods.*, 876 F.3d 1350, 1360 (Fed. Cir. 2017) ("Evidence suggesting reasons to combine cannot be viewed in a vacuum apart from evidence suggesting reasons not to combine."). Thus, even though real time image analysis on a mobile device is not required by every challenged claim, it is highly relevant that a POSA would not

have been motivated to modify the real time methods and mobile phones in Carrier and/or Salah to incorporate Maninis because, without a motivation to combine, all Petitioners grounds fail.

It is undisputed that both Salah and Carrier concern the use of software run on processors within the mobile devices to guide a user during image acquisition. *Supra* §§VI.A.-B. In this context, the guidance needs to real time—the alignment must be confirmed and communicated quickly enough to indicate to the user the moment when the camera is aligned so the right image can be captured. EX2028, ¶¶191-93; EX1002, ¶¶227-28. If it were not, the user may have moved the phone, either intentionally or unintentionally, by the time that alignment is confirmed, rendering the technique ineffective.

Maninis does not disclose that its COB neural network could be used during dental image acquisition, and Petitioner has not identified any neural network that had been trained on or used to analyze dental images for any purpose in the prior art. EX2028, ¶131, 146; EX2030, ¶23, 45. Moreover, Maninis’s computationally intensive COB neural network used a state-of-the-art GPU. *Supra* §VI.C.1. Even if the mobile phone images were analyzed only by the Maninis COB neural network for determining generic contours—a combination that Dr. Foroosh has not proposed or supported—it would take far longer than the 0.8 seconds disclosed in Maninis to run that analysis on a mobile phone in July 2017. EX2028, ¶194. As a

conservative estimate, that same analysis could take more than 6 seconds on a mobile device—per image—far too long to guide alignment as proposed by Salah/Carrier. *Id.*

Furthermore, the above timing only accounts for running the Maninis COB neural network, and not the entirely separate neural network analysis that would be required to determine the semantic contours on which Petitioner relies. Achieving the motivation Petitioner proposes could easily take twice as long and would be even more unsuitable for guiding a user to capture the desired dental images. EX2028 ¶¶195-96.

A POSA practicing Salah and/or Carrier would have known they need only achieve approximate alignment and thus, would not have been motivated to employ Maninis's COB technique when it would have precluded real time feedback to guide the user on their mobile phone, effectively rendering those alignment techniques unusable. *In re ICON Health & Fitness*, 496 F.3d at 1382; *In re Gordon*, 733 at 902.

Finally, neither Petitioner nor its expert identifies any other device or timeframe on which it alleges a POSA would have been motivated to perform the claimed image analysis by means of a deep learning device. Petitioner is too late to advance such a case now. *Intelligent Bio-Sys.*, 821 F.3d at 1360-70.

3. The Significant Time and Expense Associated With Implementing Maninis for Carrier's Alignment Technique Weigh Heavily Against Any Motivation Here

Neural networks are only useful once they have been trained, and they can only recognize what they have been trained to recognize. *Supra* §III.B. Petitioner's expert argues that, to implement Maninis, the neural network would have been trained on more than 10,000 images of patient's teeth that have been captured with mobile phones. EX1002, ¶167; EX2048, 103:23-106:5, 222:7-12; EX2028 ¶¶145, 197. Dr. Foroosh has identified no such images that existed as of July 2017. EX2048, 109:3-19; EX2028 ¶146; EX2030 ¶46; EX2039; EX2041. Instead, he suggests a POSA would have practiced Salah and Carrier *without* Maninis to gather the images over time. But Petitioner identifies no motivation to practice Salah and Carrier *alone*—indeed, if a POSA could have practiced Salah and Carrier *alone* to obtain dental images, why would they undertake to try a combination that would be exorbitantly expensive, complex, and time consuming to implement for no (or little) apparent benefit?

Even a large dental clinic would take well over a year to capture 10,000 dental images. EX2028 ¶¶147, 198; EX2030 ¶47; EX2032. Such images would then need to be anonymized—a necessary step for compliance with privacy laws, such as HIPAA, and one that could alone be prohibitively expensive. EX2028 ¶¶147; EX2030 ¶48. Once acquired and anonymized, the dental images would

need to be labeled with pixel-wise contours identifying each individual tooth by number or name, consistent with the training Dr. Foroosh proposes. *Supra* §VII.A. A POSA would have appreciated that pixel-wise, object-specific contours of medical images are challenging and expensive to apply because they require precise and extensive annotation. EX2028, ¶¶148-49, 1799; EX2030, ¶¶49-50. This undertaking likely would have also required dental anatomy training because getting the labels right is critical to the accuracy of the neural network trained on the images. EX2028, ¶148; EX2030, ¶49; EX1007 (identifying results as obtained using hand-annotated image databases); EX2048, 25:7-26:2, 144:23-145:10 (indicating that he does not have the expertise to identify which teeth are molars in the Carrier Provisional Figures).

While Petitioner suggests that manual labeling could be done “with assistance of edge detection algorithms,” Petitioner identifies no evidence that this was a recognized approach in July 2017. EX1002, ¶198. In any event, such a process would likely still require a dental professional to review and confirm each annotation, and it could easily be less efficient than a purely manual process. EX2028, ¶¶200-01. As further discussed below, Petitioner’s assertion that the learning base would be formed using data derived from the 3D models in Salah also fails to lower the burden associated with Petitioner’s proposed combination. *Infra* §VIII.F.

The significant cost, time, and complexity that would be required to obtain Dr. Foroosh’s proposed learning base weigh heavily against a motivation. A POSA would have recognized that such major challenges far outweigh any alleged benefit from more accurate contours and could have been avoided simply by using well established image recognition techniques, rather than deep learning. EX2028 ¶¶205; EX2030 ¶¶81-82; *see, e.g., Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1166 (Fed. Cir. 2006) (holding prior art must be considered as a whole, including its benefits and disadvantages).

D. A POSA Would Not Have Been Motivated to Identify Individual Teeth to Guide Image Acquisition in Either Carrier or Salah

Despite Carrier’s teaching that image alignment is achieved using overlays, Petitioner reads into Carrier an analysis that is never disclosed: creating a list of “required teeth” for an image; checking the image to determine the visible teeth; and comparing the list of identified teeth to the list of “required teeth” to guide image acquisition. EX1002, ¶¶80-82, 86, 115, 119-120. A POSA who—unlike Dr. Foroosh—is familiar with the challenges faced by dental practitioners when acquiring images, would not read Carrier to suggest any such method. EX2028, ¶¶206-11; EX2030, ¶¶76-82; *supra* §II.

Carrier states that the “overlay with an outline of teeth in a predetermined view” provides “information such *as required visible teeth* in the predetermined

view.” EX1006, [0060]; EX1005, [0105]. A POSA would have recognized that, unlike checking off a list of teeth visible in an image, the overlay technique guides the approximate distance, angle, and view. EX1006, [0060]; EX1005, [0105]; EX2028, ¶¶208-11; EX2030, ¶¶81-82. Carrier further teaches that such an overlay can be used to capture high quality dental photographs, even though the outline might have a different number of teeth than in the dental arch. EX1006, [0060]; EX1005, [0105]; EX2028, ¶¶209-10; EX2030, ¶¶79-80.

Indeed, counting teeth is irrelevant to guiding the capture of “standard orthodontic images,” a process that Carrier purports to improve. As Dr. Kusnoto explains, standard orthodontic images are primarily concerned with the approximate alignment of the “view,” not the presence or number of specific teeth. EX2030, ¶¶78-82. That is exactly because, as noted above, patients have different numbers of teeth, e.g., due to injury or disease. EX2030, ¶34. If a patient were missing a tooth, Dr. Foroosh’s tooth counting method would be unworkable—it is impossible to detect “all required teeth” in a dental image if not “all required teeth” are present in a patient’s mouth. EX2030, ¶79.

Finally, Petitioner’s hindsight-driven efforts to use Carrier to justify determining semantic contours in dental images should be rejected. Its expert admitted Carrier does not expressly disclose detecting contours associated with individual teeth (*i.e.*, semantic contours), and that a POSA would have understood

Carrier's overlay technique could be accomplished without doing so. EX2048, 113:21-116:2; EX2028, ¶¶121-23, 212-13. Petitioner identifies no other reason why a POSA would have been motivated to determine semantic contours, nor any advantage to doing so. For the reasons discussed above, a POSA would have had no such motivation. *Supra* §VIII.C.

E. Petitioner's Semantic Contours Are Not "Image Attributes" (Claim 7)

While claim 7 requires training on historical images having "*image* attribute values," Petitioner's approach of training on "semantic contours" necessarily requires training on historical images labeled with "*tooth* attribute values." As Dr. Mongan explains, however, the neural networks in Maninis that determine semantic contours are trained *only* on "tooth attribute values" (pixel-wise annotations) and are *incapable* of learning from *any* "image attribute value" (including a list of teeth present in the image). EX2028, ¶¶219-32. Thus, although an image attribute value can be determined from the identified tooth attributes values *after* the image has been analyzed, in Dr. Foroosh's proposed combination, the historical images in the learning base *cannot* comprise those same image attribute values—as required by claim 7—only tooth attribute values. Accordingly, even if the Maninis COB neural network functioned as Dr. Foroosh (incorrectly) proposes, or Petitioner relied on the other neural networks in Maninis, alone or in

combination with the Maninis COB neural network—grounds entirely absent from the Petition—the proposed combination still fails to disclose all elements of the invention.

Claim 7 depends from claim 1 and requires that step b') comprise additional steps regarding the creation of the learning base, the training of the deep learning device, and the deep learning device's analysis of the analysis image. EX1001, cls. 1, 7. Importantly, claim 7 requires that each “historical image” in the learning base comprise an “image attribute value” and that “at least one probability relating to *said* image attribute value” is determined during analysis. *Id.* Accordingly, the same “image attribute value” must be *both* labeled on the historical images in the learning base *and* related to a probability determined by the deep learning device for the analysis image. Thus, in contrast to claims 2-6, which embody the “detailed analysis approach” described in the '409 patent, claim 7 embodies the “global analysis” approach. *Supra* §IV. (contrasting “**detailed analysis**” approach, wherein the deep learning device is trained on and determines “tooth zones” and corresponding “**tooth attribute** values” with the “**global analysis**” approach, wherein the deep learning device is trained on and determines “**image attribute** values”); EX2028, ¶219.

Petitioner's proposed combination of Salah, Carrier, and Maninis uses images in the learning base labeled with semantic contours (or boundaries)—

specifically, with contours identifying the tooth bounded by that contour. EX1002, ¶177 (referring to “section IX.D” “discussing annotations in the context of claim 3”); *id.*, ¶151 (describing these semantic contours as satisfying the requirement of “historical tooth zones, to each of which ... a tooth attribute value is assigned”); Paper 2, 44-45, 50-52. Consistently, Dr. Foroosh asserted that the “probabilities” determined by the deep learning device concern the presence of a “set of tooth edges” that “define analysis tooth zone[s]” and “that ha[ve] been determined to contain a particular tooth.” EX1002, ¶¶157-58; *id.*, ¶181 (referring to “section IX.D.3”). When addressing Step 7(3’), Petitioner thus appears to suggest that there are **two values** “related to” these “probabilities” that satisfy the “said image attribute value” limitation of claim 7: **(1)** “the teeth identified within those boundaries” and **(2)** “the distance between the edges of the tooth and the overlay.” EX1002, ¶181.

(1). As to **the first**, “the teeth identified within those boundaries” are “*tooth* attributes,” not “*image* attributes” as Petitioner confirms when addressing claims 3, 8, and 9. EX1002, ¶¶157-58, 196-200, 210-211; Paper 2, 44-45, 59-61, 65. Specifically, the semantic contours constitute “tooth zones” (segments) each assigned a “tooth attribute” (tooth identification). The identification of a tooth associated with a particular segment or “zone” of the image does not “relate[] to the whole image” and is thus not an “image attribute.” EX1002, ¶73; Paper 1, 15-

16. This determination of a tooth attribute cannot satisfy the requirement in Step 7(3') that the deep learning device “determine, for said analysis image, at least one probability relating to said *image attribute value*.” EX2028, ¶¶220-21.

It may be that Petitioner meant to argue that a *list* of the teeth that are present in the image, as derived from “tooth attributes” (tooth identifications), is the “image attribute value,” as Petitioner argues elsewhere. *E.g.*, EX1002, ¶74. Although the '409 patent discloses that such a list can be an “image attribute value” within the meaning of the patent, it *cannot* satisfy the requirements of claim 7, which requires that the historical images in the learning base are labeled with the same “image attribute value.” EX1001, 26:21-23.

As Dr. Mongan explains, the neural networks disclosed in Maninis, which determine semantic contours or semantic segmentations, are not capable of being trained on images labeled with *any* “image attribute value,” including a “list of tooth numbers.” EX2028, ¶¶222-26. Those neural networks must be trained on bitmap vectors with values assigned for each pixel corresponding to the class of the object to be recognized. In other words, for each pixel in which a given object is depicted in an image, the pixel value would be set to the numeric identifiers of the object's class (*e.g.*, tooth number). EX2028, ¶¶224-26; EX2020. No other information can be used to train, or be output by, such a neural network. EX2028, ¶¶224-26.

These neural networks for determining semantic boundaries are thus *incapable* of being trained on a value representing anything other than values to be assigned to each pixel, which excludes any value that “relates to the whole image” like a “list of tooth numbers” for the image. EX1001, 3:26-27; EX1002 ¶73; Paper 1, 15-16; EX2028, ¶228.

As explained above, the Maninis COB neural network is also trained on a bitmap of values—except that each pixel value is either “0” and “1” because the COB neural network does not recognize object classes—and is thus equally incapable of training on such an “image attribute.” EX2028, ¶227.

(2). The **second** apparent “image attribute value” that Petitioner identifies—“the distance between the edges of the tooth and the overlay”—likewise fails because Petitioner never even *proposes* that such an attribute would be included in a historical image in the learning base. Petitioner has thus failed to identify an “image attribute value” that satisfied both limitations of Step 7(1’) and 7(3’). EX2028, ¶¶229.

In addition, as with the list of tooth numbers, it is impossible to incorporate such an “distance between the edges of the tooth and the overlay” into the historical images for training any of the neural networks disclosed in Maninis. EX2028 ¶230.

In sum, because Petitioner has proposed that the “deep learning device” is one in Maninis that recognizes contours or semantic contours rather than one that

recognizes wholistic image features (*e.g.*, object recognition)—and which would be trained on a learning base comprising the same—it is impossible for those neural networks to satisfy the limitations of claim 7, which requires “each historical image compris[es] an ... ‘image attribute value.’” EX2028, ¶¶231-32. Petitioner has thus failed to demonstrate that claim 7 is disclosed by the prior art or that a POSA would have been motivated to combine the ground references with a reasonable expectation of success.

F. A POSA Would Not Have Been Motivated to Create a Learning Base by Altering the Method Disclosed in Salah (Claims 8 and 9)

Petitioner agrees that, to train a deep learning device on semantic contours—*i.e.*, “tooth zones” labeled with “tooth attributes”—a POSA would have needed to make “pixel-wise annotations of which regions contain which [teeth].” *E.g.*, EX1002, ¶¶197-98. Petitioner asserts that it would have been obvious to “compose” such a learning base using the process described in ’409 patent claims 8 and 9. Paper 1, 52-65; EX1002 ¶¶183-211. It suggests that a POSA would have been motivated to practice the method described in Salah, but rather than transferring information from the updated images to the 3D model of the patient’s teeth, a POSA would have transferred information from the 3D model to the updated images. *Id.* However, Petitioner identifies no motivation to practice this method, and ignores the disadvantages of doing so. EX2028 ¶¶214-218.

As an initial matter, Salah does not disclose that the 3D models or reference images are labeled with any “tooth attributes” (such as “tooth number”) such that they could even provide information that could be transferred to updated images to create labeled, historical images. Indeed, a POSA would have understood that Salah’s method does not require determining such information. EX2028, ¶215. Nor does Petitioner point to any disclosure in Salah of such an approach. Petitioner’s cited passages concerning the determination of contours and the use of “regist[r]ation marks” to crop images are irrelevant here. *Id.*; EX1002, ¶197 (citing EX1008, 48:9-19, Fig. 6b); EX1002, ¶198 (citing EX1008, 33:27-34:2).

Furthermore, to make the combination Petitioner proposes, a POSA not only would have needed a reason to combine Salah, Carrier, and Maninis in the proposed manner for claim 1, but it would *also* have needed a reason to practice Salah *alone* for an indefinite period of time to gather the necessary training images. But Petitioner suggests only that a POSA *could* do so, which is legally insufficient. *Belden*, 805 F.3d at 1073. And there are several reasons a POSA would *not* have done so.

The learning bases disclosed in Maninis were annotated by humans. EX2028 ¶217. Petitioner identifies no evidence that a POSA in July 2017 would have rejected this approach, and instead employed images with pixel-wise contours labeled *by a computer algorithm*. Because it was known that the quality of the

training images directly impacts the quality of the neural network’s analysis, a POSA would not have been motivated to do so. *Id.* A POSA would have instead wanted to confirm that the contours were accurately applied to the training images—undermining any possible motivation to employ Salah as alleged by Petitioner to produce the learning base here. *Id.*; EX2030, ¶49.

G. The Ground References Fail to Disclose that the “Analysis Image Is Analyzed and Checked in Real Time” (Claim 14)

Petitioner’s only theory for how its proposed combination satisfies the “real time” requirement of claim 14 is that it would operate in the same manner in which Carrier and Salah contemplate “real time” analysis—*i.e.* quickly enough to provide live feedback during image acquisition, prior to capturing an image. Paper 1, 68-69; EX1002, ¶¶226-28; EX2048, 69:11-74:12 (confirming no understanding of “real time” other than as disclosed in Carrier and Salah). As described above, Petitioner’s proposed combination is inoperable for that purpose. *Supra* §VII.B. (demonstrating that Petitioner’s combination would not work for Carrier’s and Salah’s “real time” analyses). Petitioner offers no evidence or opinion regarding how its combination could otherwise meet the “real time” limitation. *Supra* §V.B. Accordingly, Petitioner has failed to demonstrate that claim 14 is obvious. EX2028 ¶¶223-35.

IX. Conclusion

Patent Owner respectfully submits that the Board should find all the challenged claims are patentable over the grounds raised in the Petition.

Date: May 28, 2024

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Certificate of Word Count

The undersigned hereby certifies that the portions of the above-captioned **DENTAL MONITORING SAS'S PATENT OWNER'S RESPONSE** specified in 37 C.F.R. § 42.24 has 13,982 words in compliance with the 14,000 word limit set forth in 37 C.F.R. § 42.24. This word count was prepared using Microsoft® Word for Microsoft 365 MSO.

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Certificate of Service

Pursuant to 37 C.F.R. §§ 42.6(e), the undersigned certifies that on May 28, 2024, a complete copy of **DENTAL MONITORING SAS'S PATENT OWNER'S RESPONSE** was served via electronic mail on the following counsel of record for Petitioner at the email addresses: mrosato@wsgr.com, margenti@wsgr.com, and pmedley@wsgr.com, as indicated in the Petition for electronic service to the following Petitioner counsel:

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